

DEEP ENERGY RETROFITS: CALIFORNIA CASE STUDIES

Jeremy Fisher & Brennan Less – LBNL

Aug 16, 2011

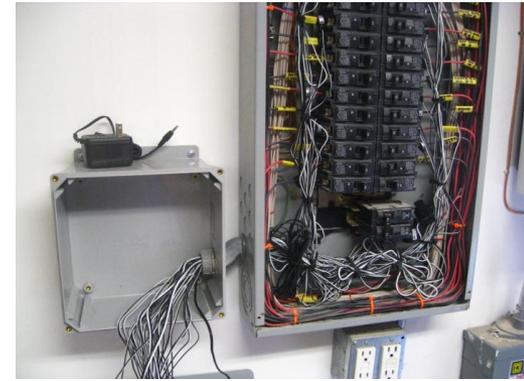
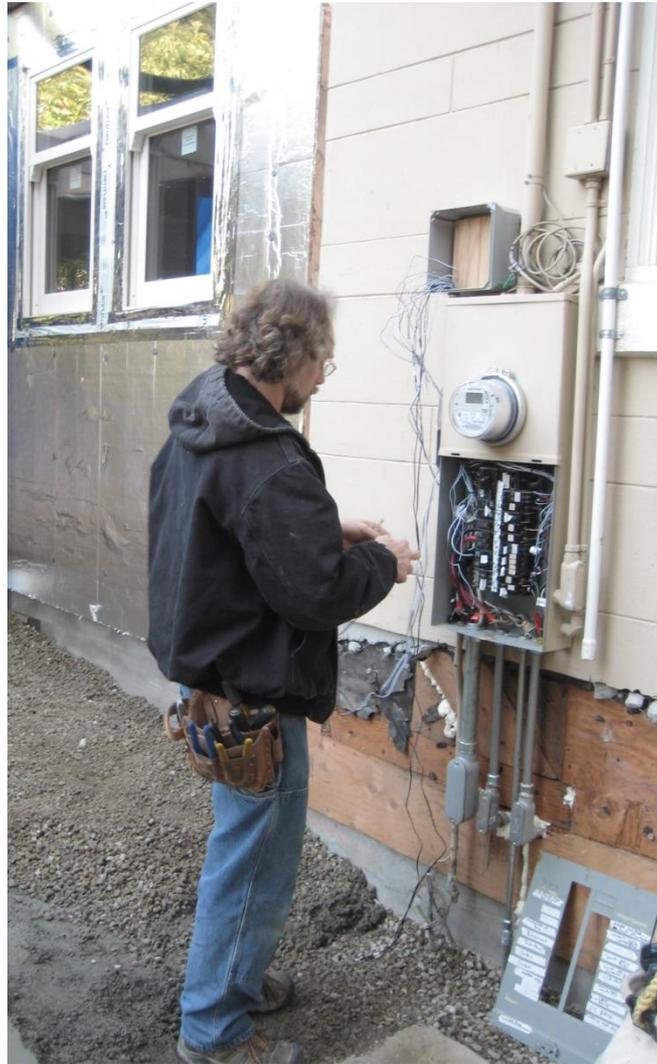
LBL Deep Energy Retrofit Monitoring

- 10 residential retrofits aiming at 70% or more energy savings.
- Goal: To show how energy is actually being used in these northern California deep energy retrofit homes.
- End-use energy monitoring
- 1 year minimum monitoring period

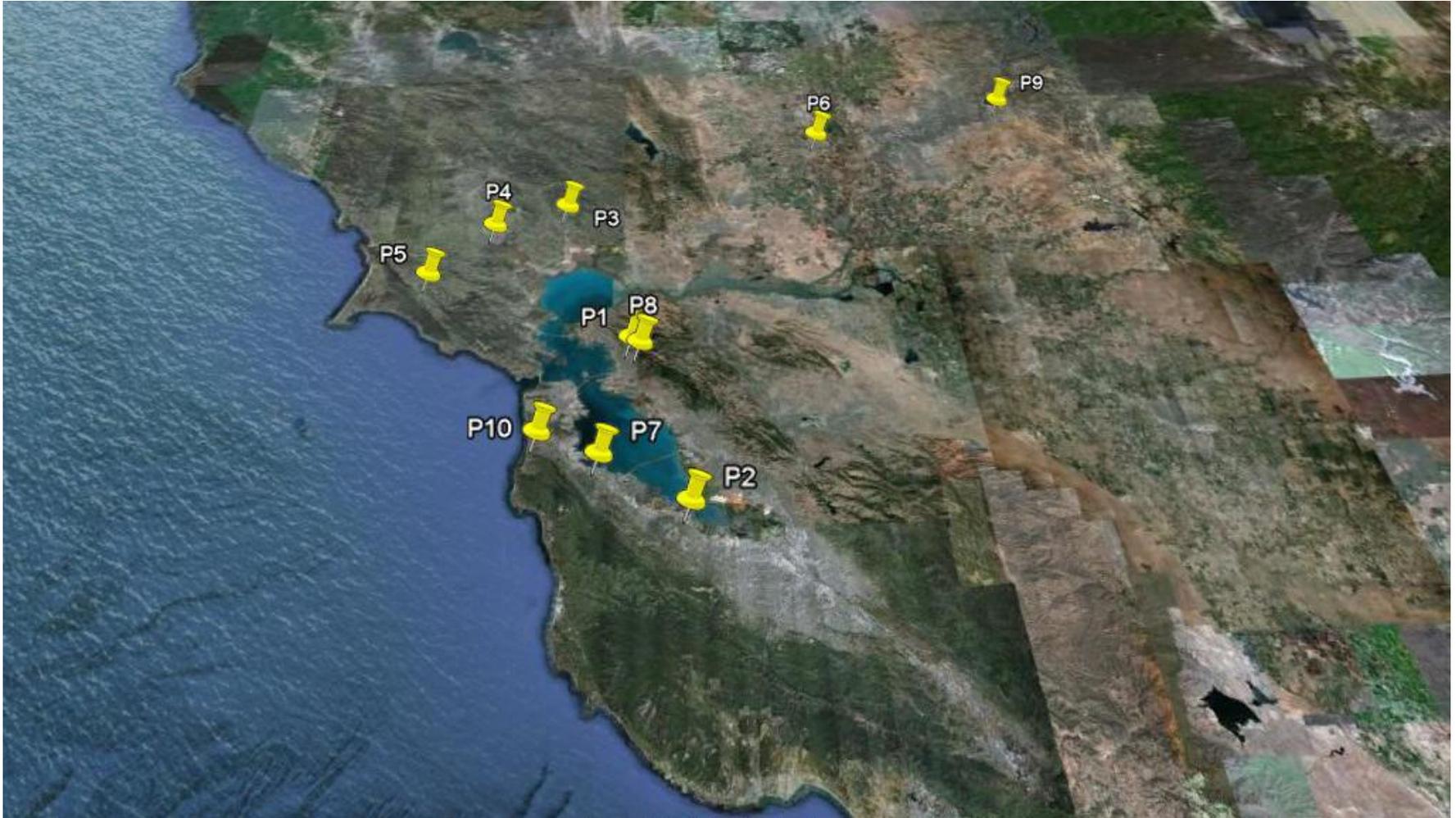
How do we talk about performance?

- **Energy per house** vs. per square foot vs. per occupant
- **Site** vs. Source energy
- Separation of renewable energy
- Nearly all case studies are significant remodels, not solely energy retrofits or home performance upgrades
 - Changes in square footage and physical layout
- Issues with pre-retrofit vs. post-retrofit comparison
 - Ownership/Access to utility data
 - Comfort
 - Occupancy
 - Weather
- Issues with end-use monitoring
 - Circuit panel layout and combined electrical loads
 - Monitoring equipment limitations
 - Complex combined HVAC/DHW/Solar systems
 - Load calculation by subtraction is problematic

Monitoring Equipment



Project Locations



P1 Project Description

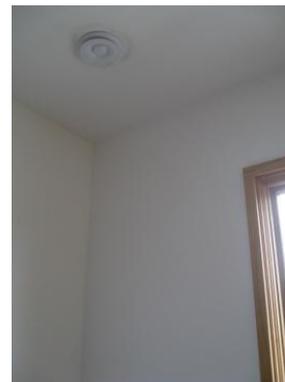
1904 Craftsman Bungalow Berkeley, CA

Pre: 960ft² → Post: 1,630ft²

- The existing home was un-insulated with one natural gas floor heater on the 2nd level
- The house was lifted, and the ground floor was rebuilt to legal height
- The retrofit was guided by the European *Passive House* design principles
- 4 bedroom, 2 bath, 4 occupants, home office



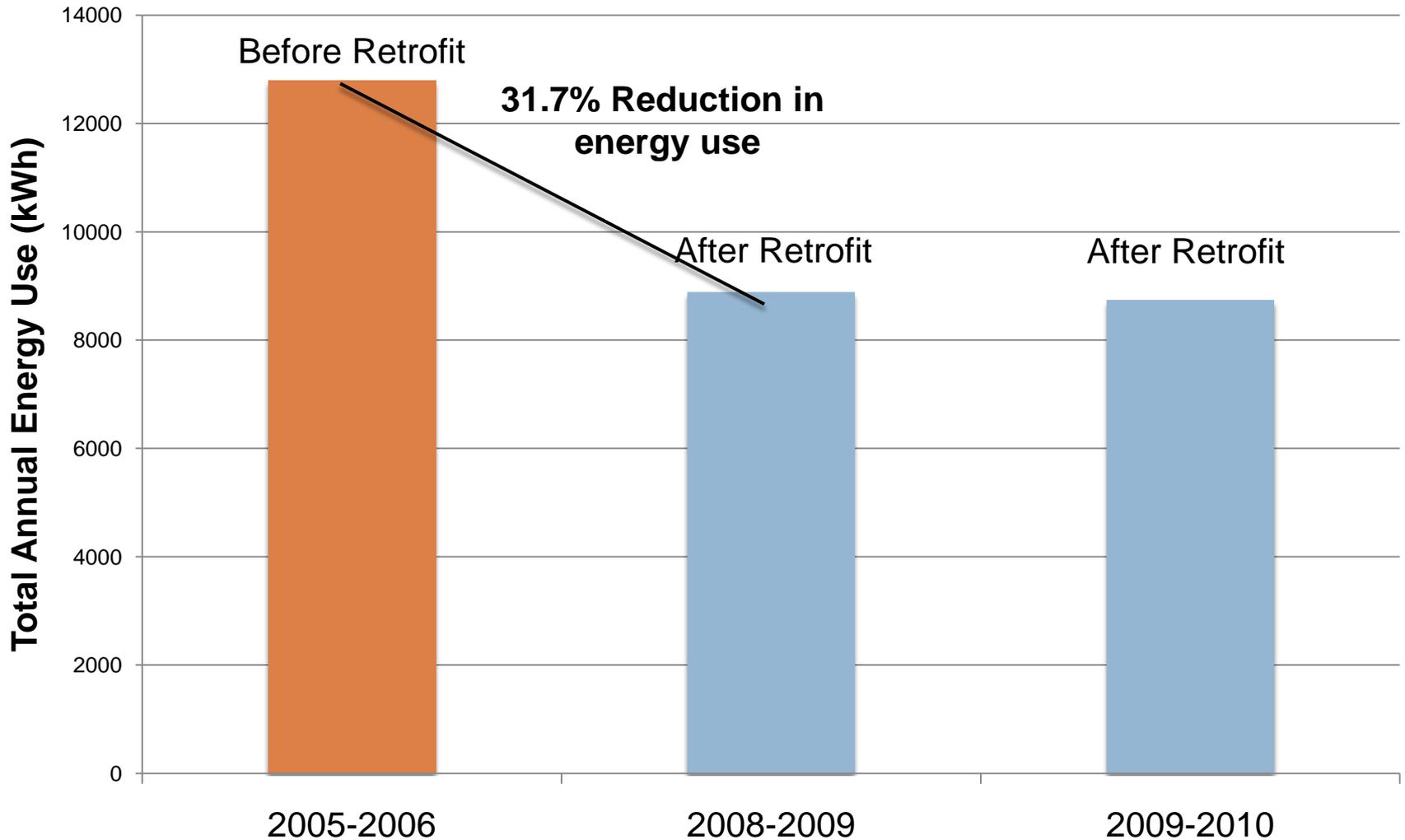
P1 Retrofit Description



P1 Retrofit Achievements

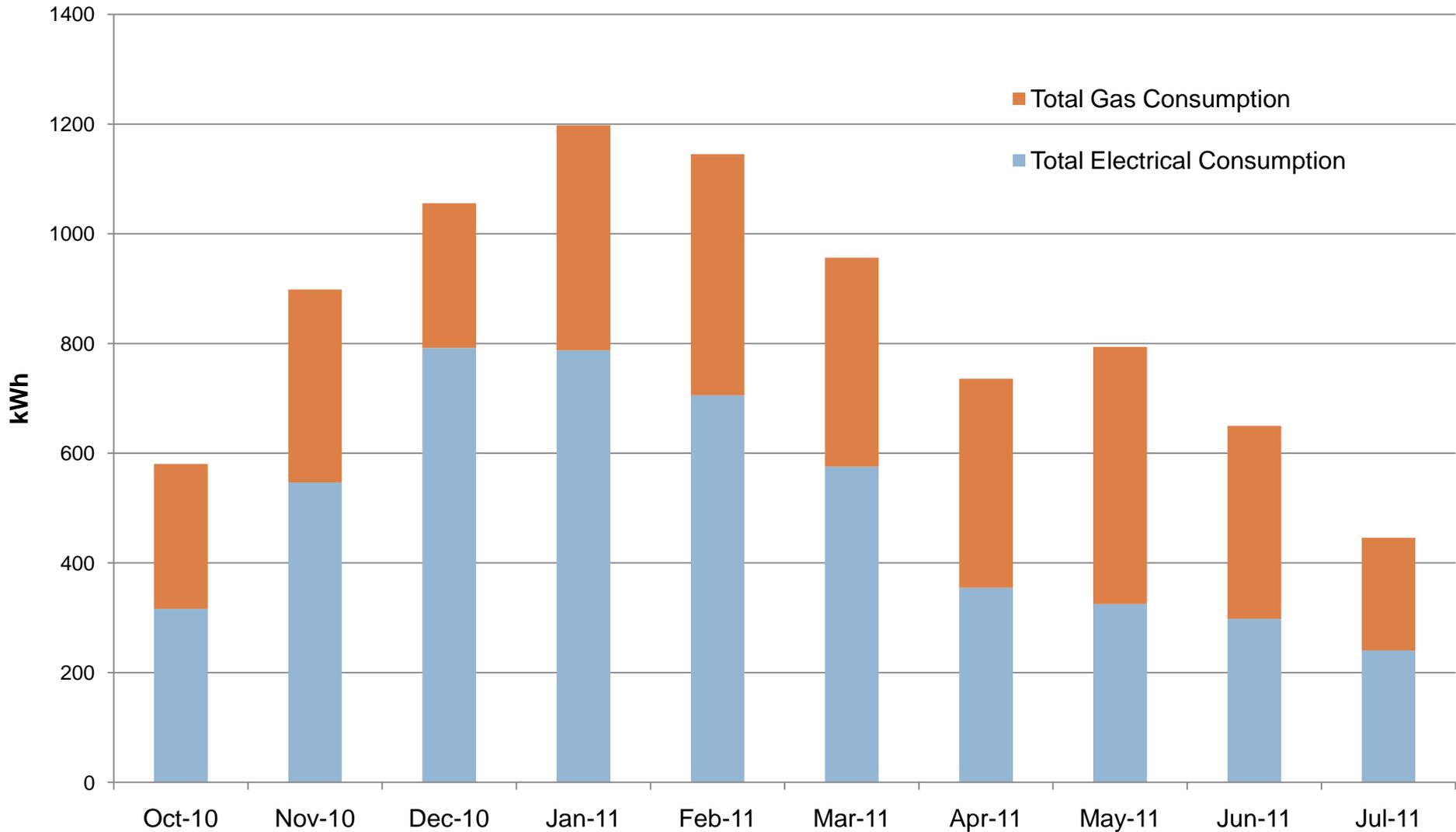
- Conditioned entire home, greatly improving comfort
- Doubled usable/legal space
- Addition of home office
- Addition of 2 teenage occupants
- Aesthetic improvements
- Pioneered Passive House retrofit techniques in the Bay Area
- Significant energy reductions

P1 Historical Utility Bill Data

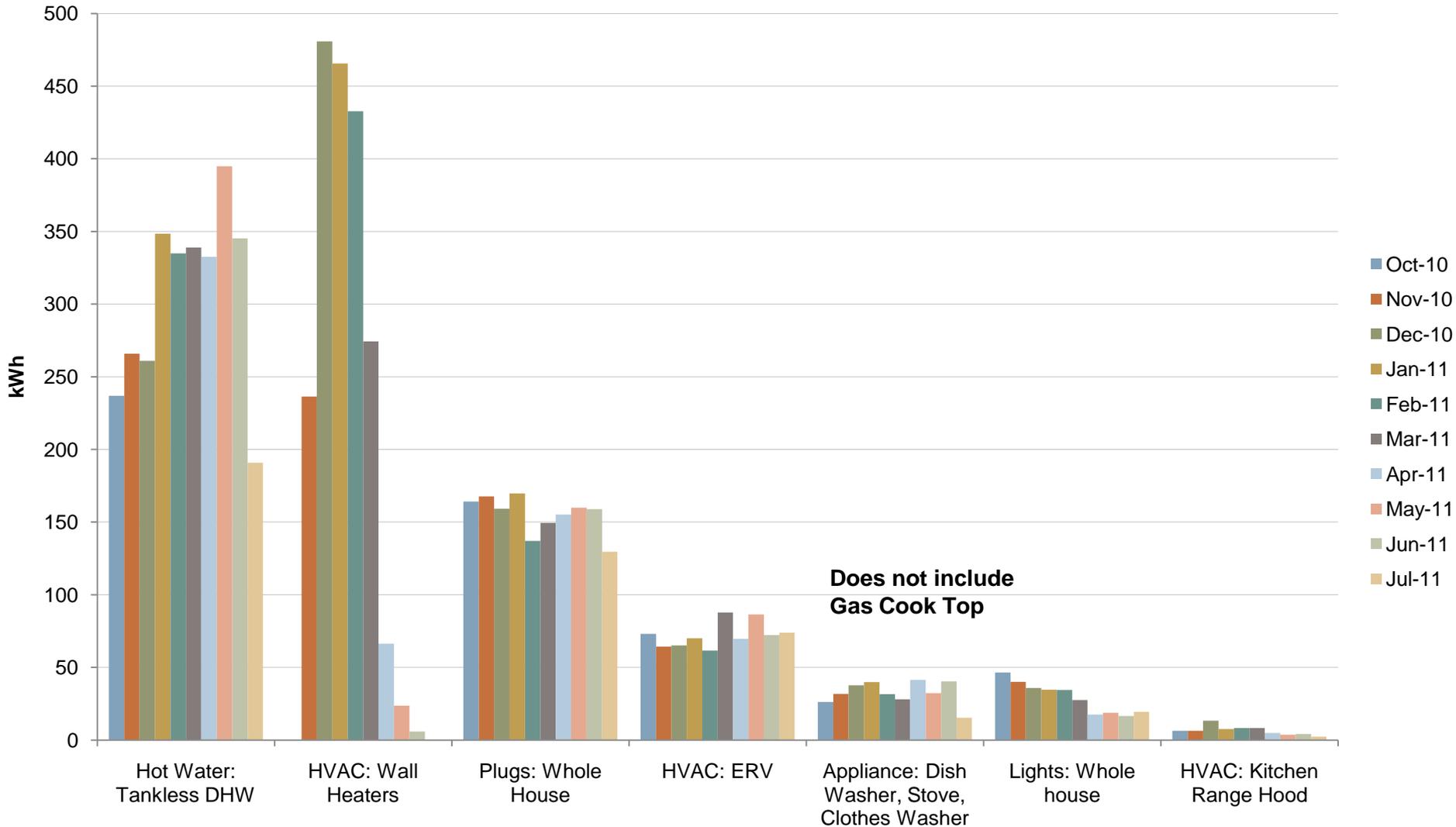


P1 Energy Use Data

Whole House Energy Usage



P1 Energy Use Data



P2 Project Description

1936 English Tudor Revival- Style Home Palo Alto, CA

Pre: 2,780ft² → Post: 2,780ft²

- The existing home was considered architecturally significant, and efforts were made throughout the project to maintain its historical character.
- 5 bedroom, 3 bath, variable occupancy, home office



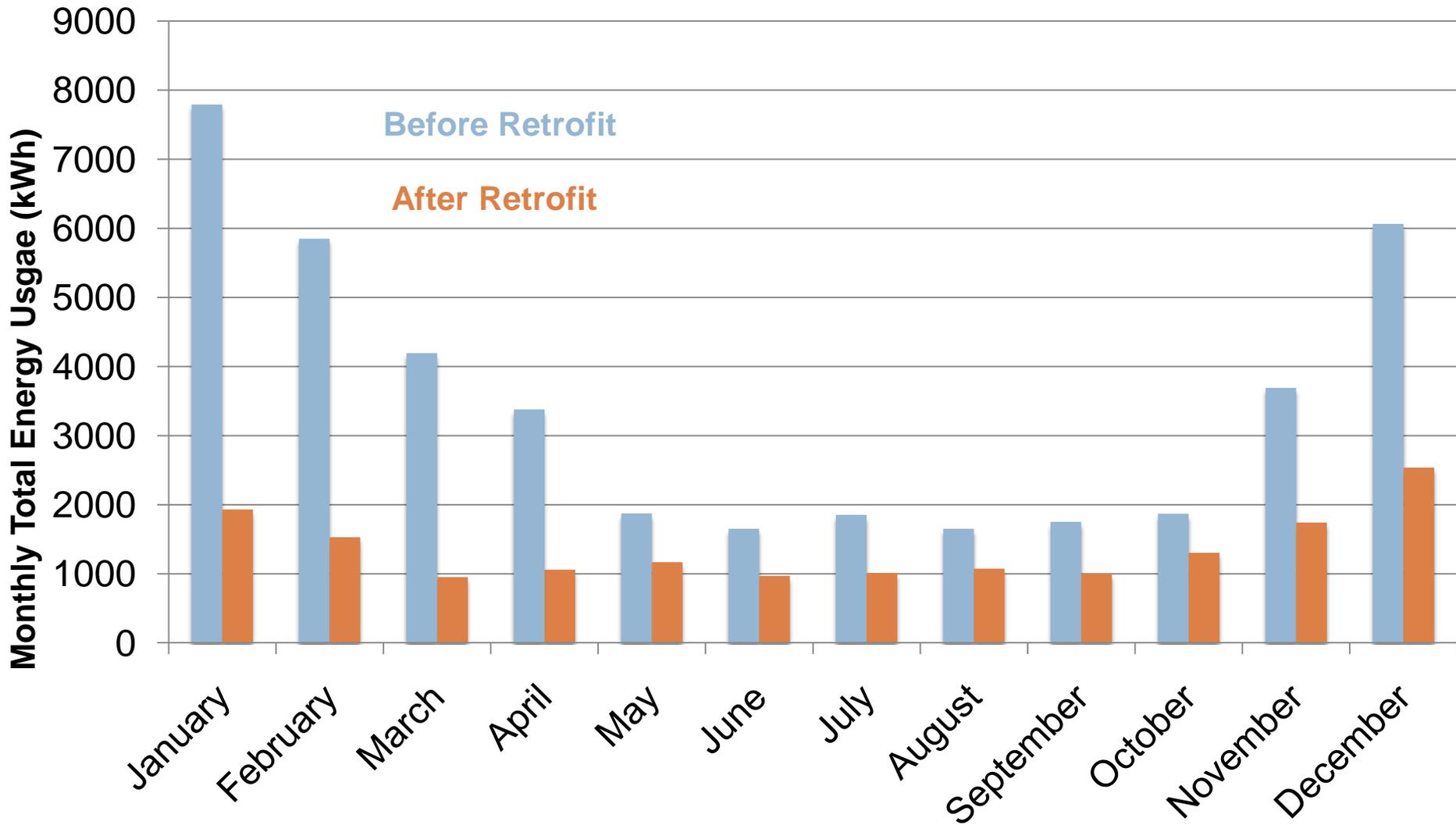
P2 Retrofit Description



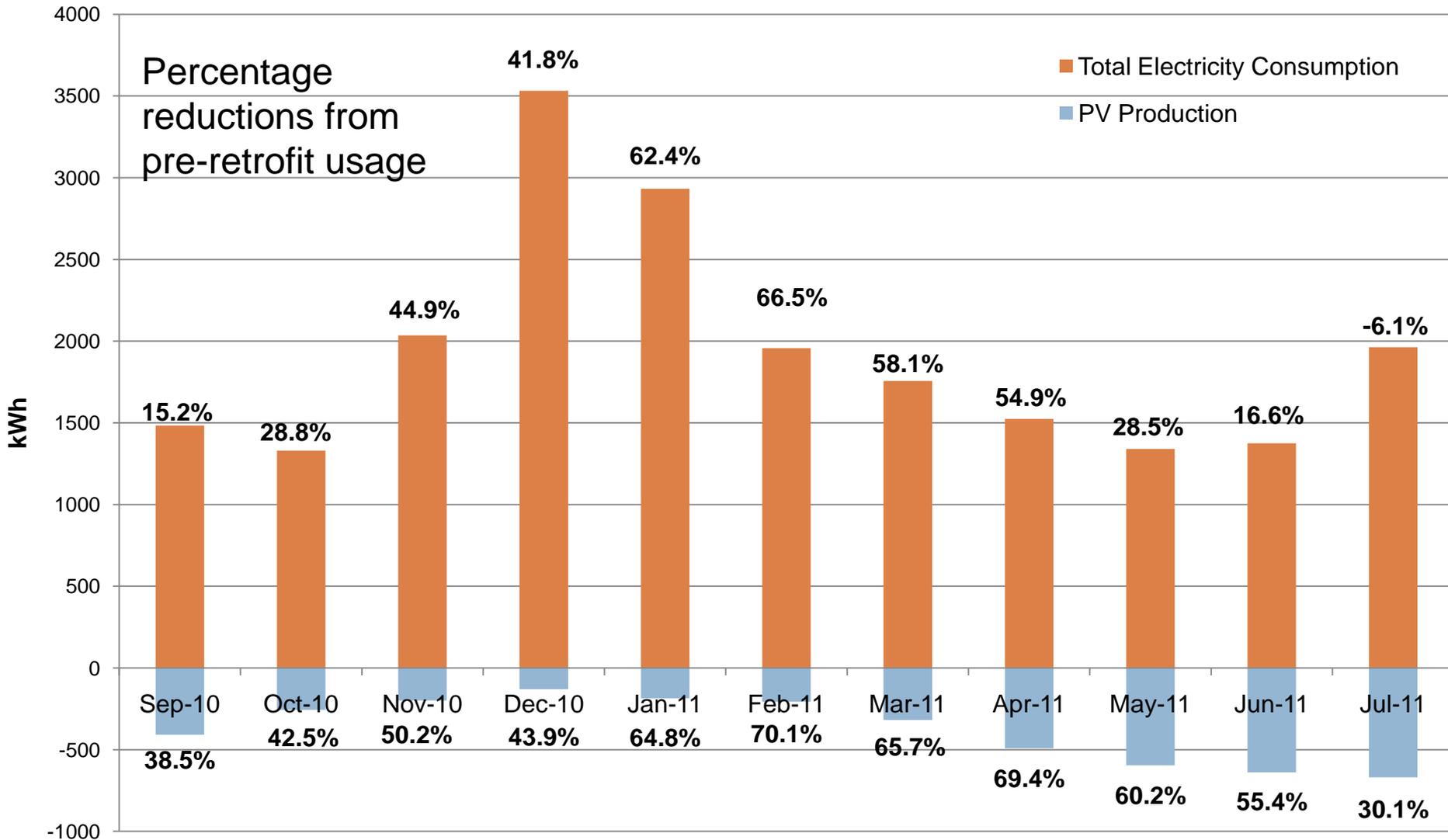
P2 Retrofit Achievements

- Conditioned entire home, adding cooling
- Maintained historical character
- No expansion of building footprint
- Was a high energy user, so even though it is still higher than other projects, the savings are significant

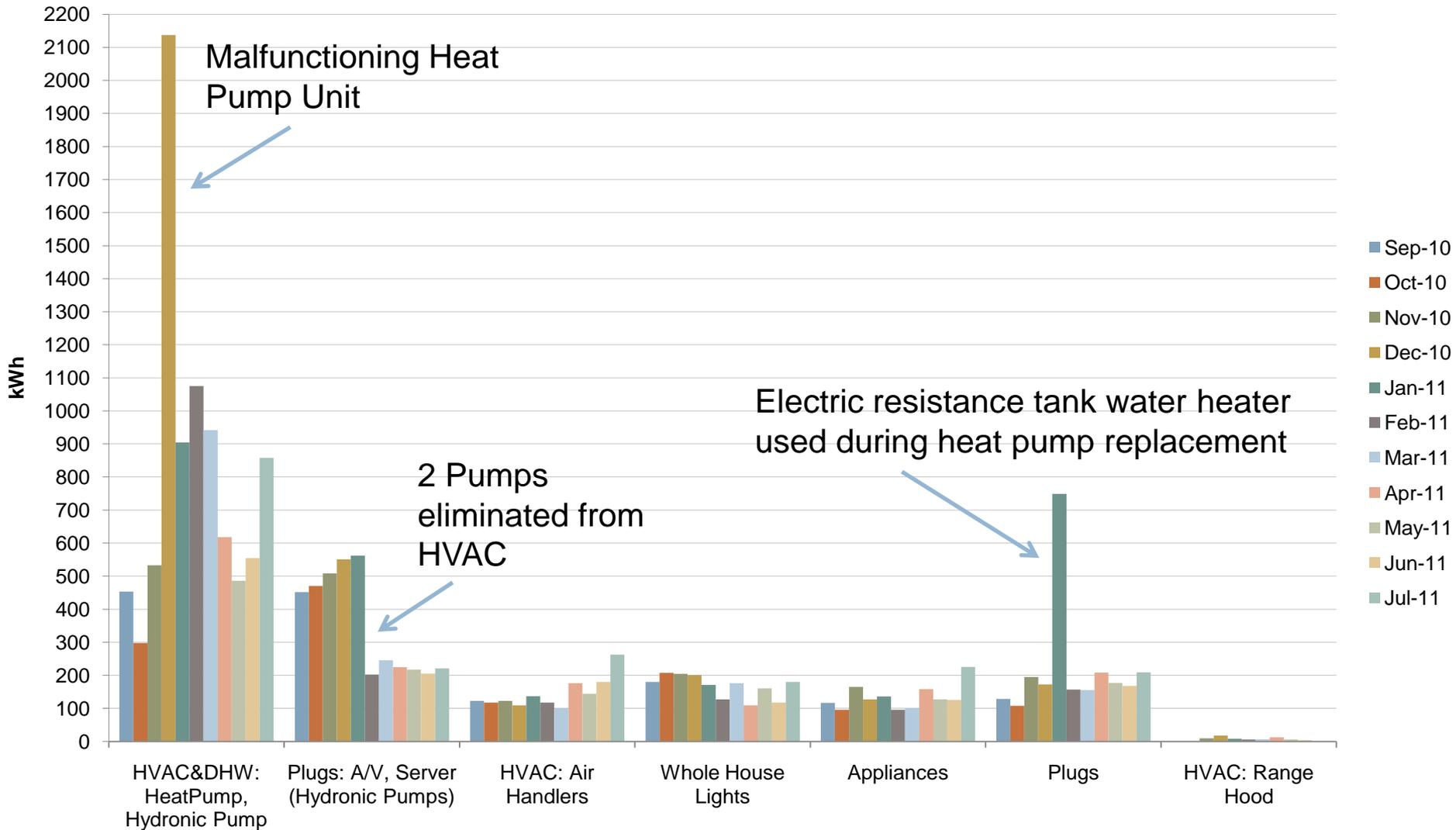
P2 Historical Utility Bill Data



P2 Energy Use Data



P2 Energy Use Data



P3 Project Description

Two 1958 ranch-style homes connected by a covered breezeway

Pre: 1,933ft² → Post: 2,342ft²

- The two separate structures were connected by enclosing the breezeway, forming a U-shaped home with a central courtyard
- 3 bedroom, 2 bath, 1 Occupant, home office



Image courtesy of www.solar-knights.com



P3 Retrofit Description



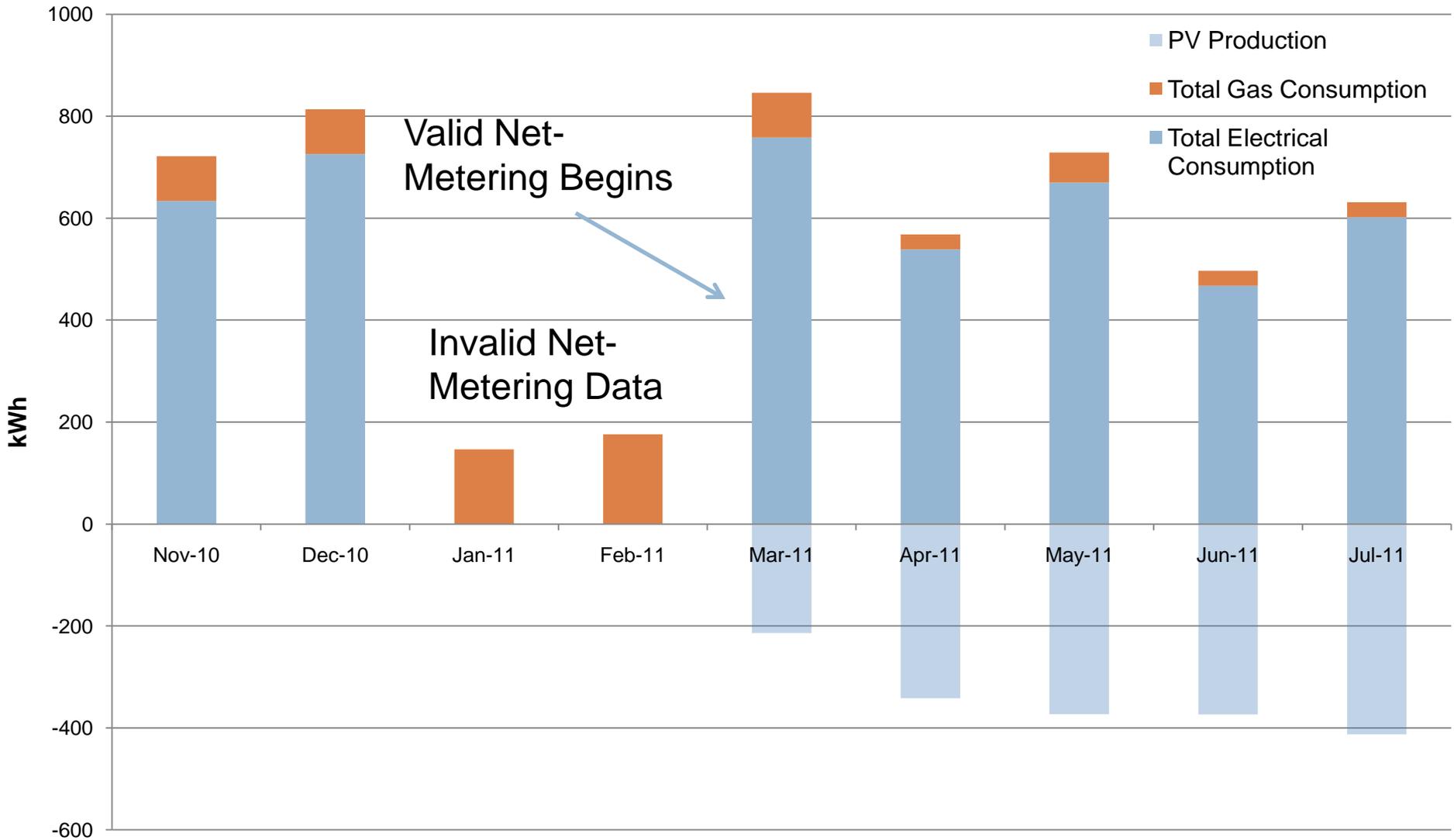
P3 Retrofit Description



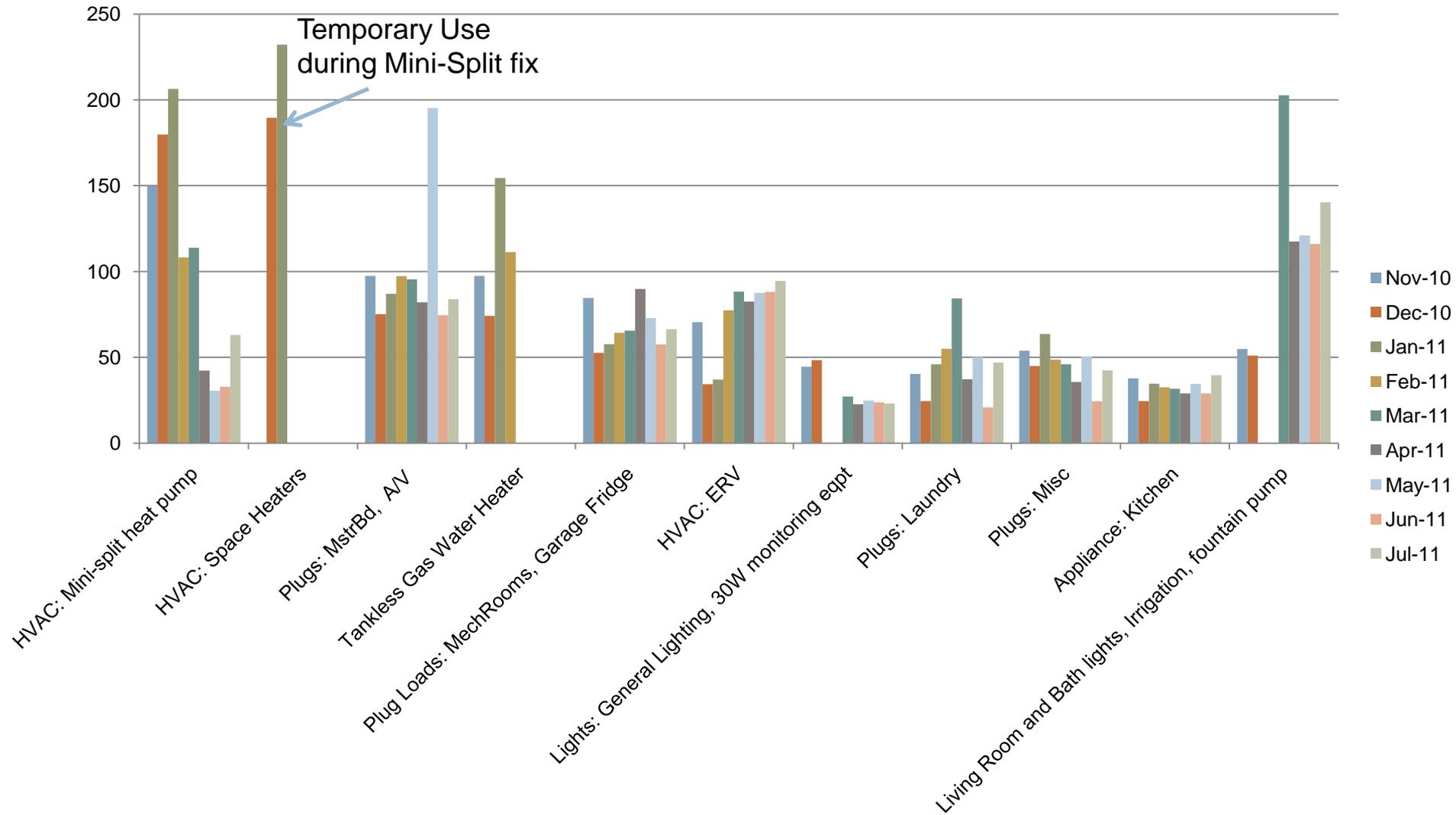
P3 Retrofit Achievements

- First certified Passive House retrofit in the country
- Low heating energy despite challenging U-shaped layout with high surface to volume ratio
- Turned two relatively undesirable homes into one beautiful, highly energy efficient home.
- Serves as a regional model for deep energy retrofits

P3 Energy Use Data



P3 Energy Use Data



P4 Project Description

1940's Bungalow Petaluma, CA

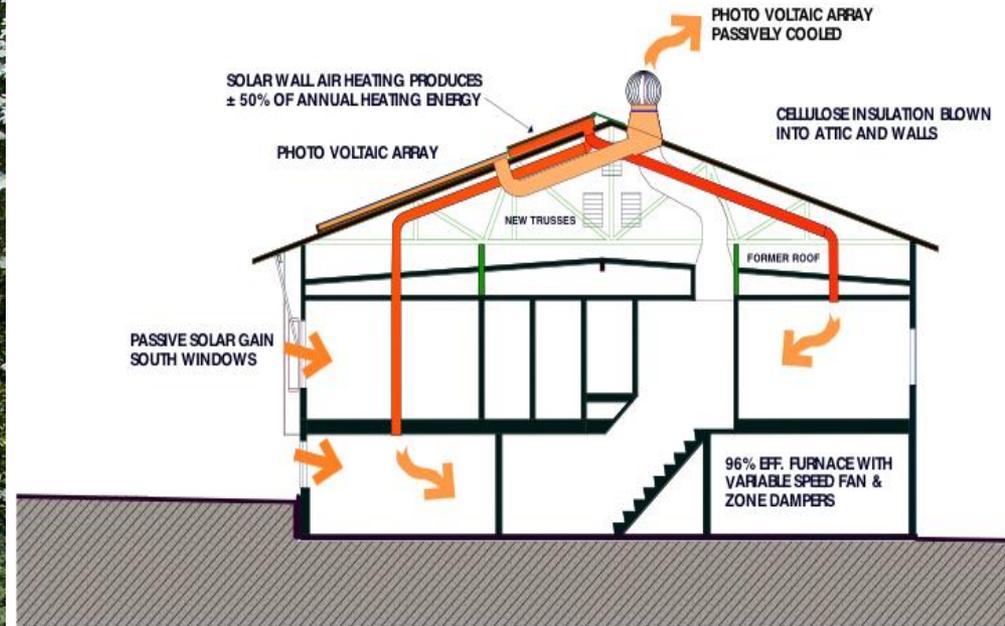
Pre: 1,540ft² → Post: 2,510ft²

This retrofit was carried out in 3 phases:

- 1- In 1998 prior to moving in
 - 2- In 2004 renewable energy was added
 - 3- In 2010 a structural/seismic retrofit
- A 4th phase is in planning, including a solar combisystem with a back up biomass boiler for total carbon neutrality.
 - 2 bedroom, 2 bath, 2 occupants, home office



P4 Retrofit Description



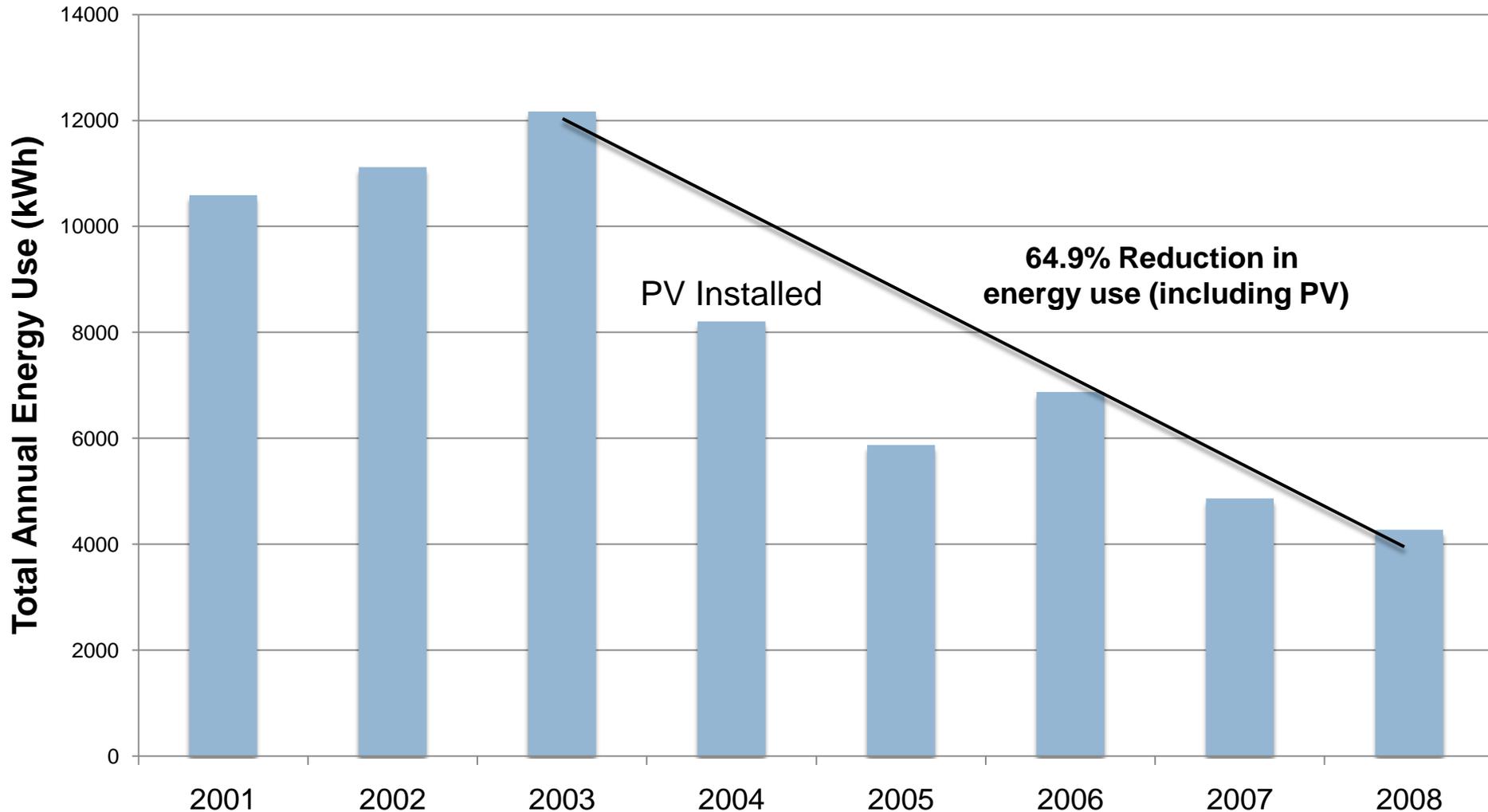
WINTER FEATURES • BUILDING SECTION

AIM ASSOCIATES
100 FAIR STREET, PETALUMA CALIFORNIA

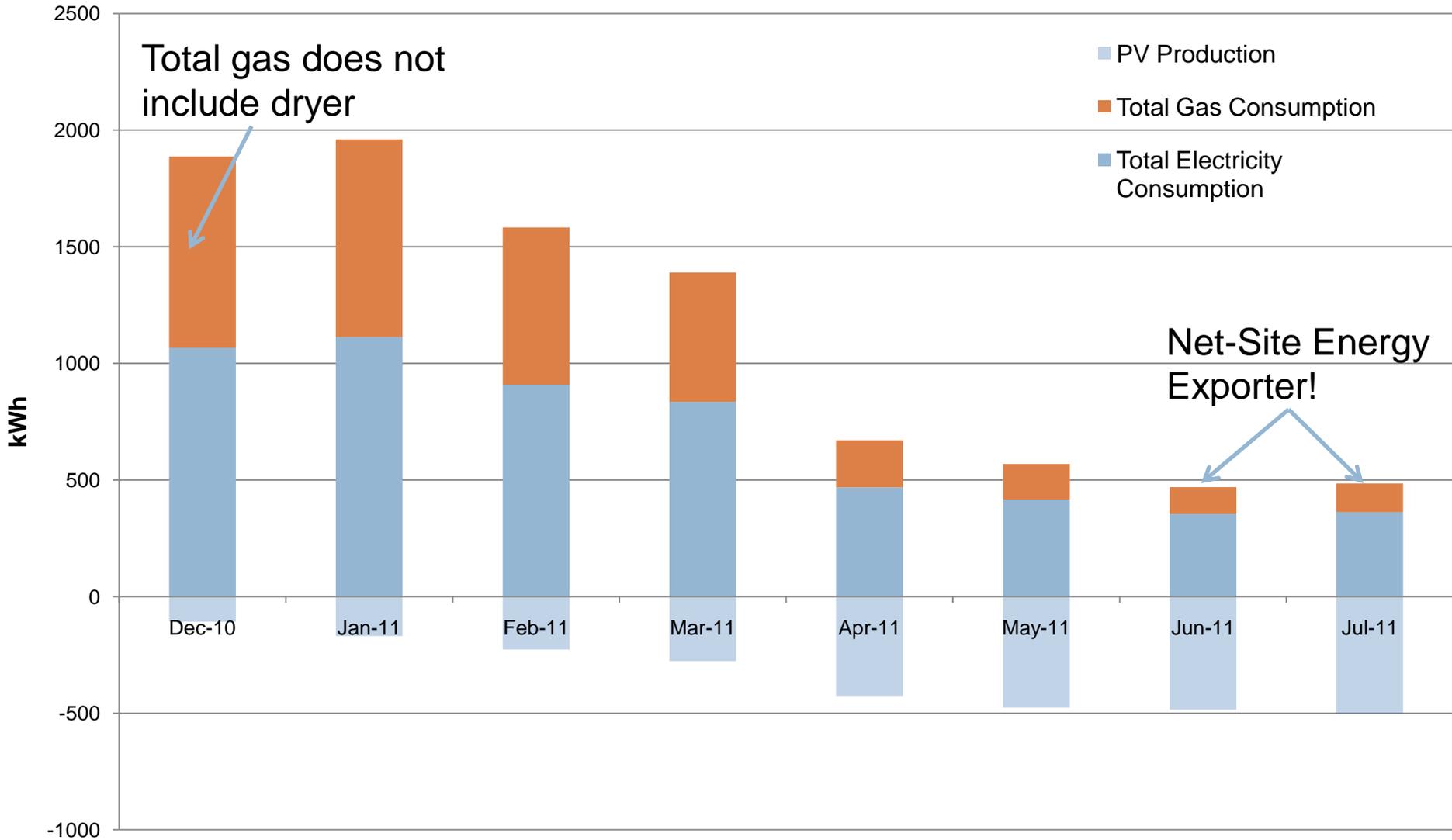
P4 Retrofit Achievements

- Staged approach to retrofit, learning from experience and experimentation
- Pre-retrofit utility data is not available, yet major energy reductions were achieved from phase one to phase three
- Added home office
- Special attention to improving IAQ and other sustainable practices
- Added 1/3 of floor area while significantly reducing energy use

P4 Historical Utility Bill Data



P4 Energy Use Data



P7 Project Description

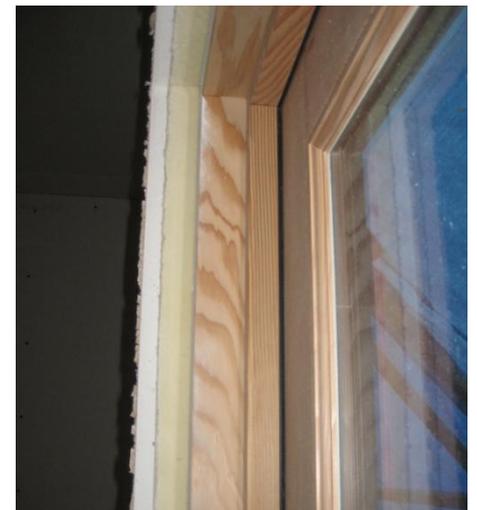
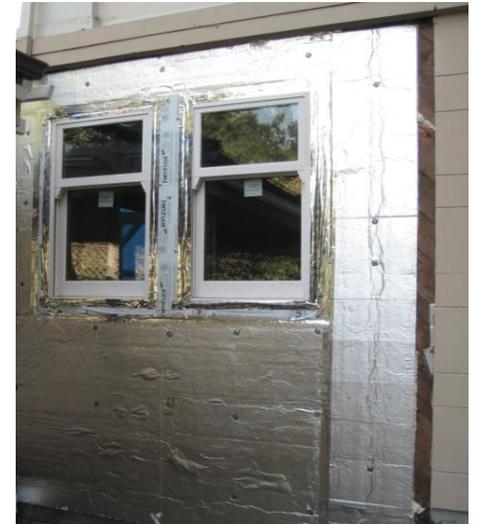
1910 Craftsman Bungalow San Mateo, CA

Pre: 3136ft² → Post: 3288ft²

- House within a house concept, using kitchen and rear zone as primary living space in winter. Insulated entire home, maintaining architecturally significant interiors, increased comfort and hope to achieve 1000 home challenge with future PV installation.
- 3 bedroom, 2.5 bath, 2 Occupants



P7 Retrofit Description



P7 Retrofit Description

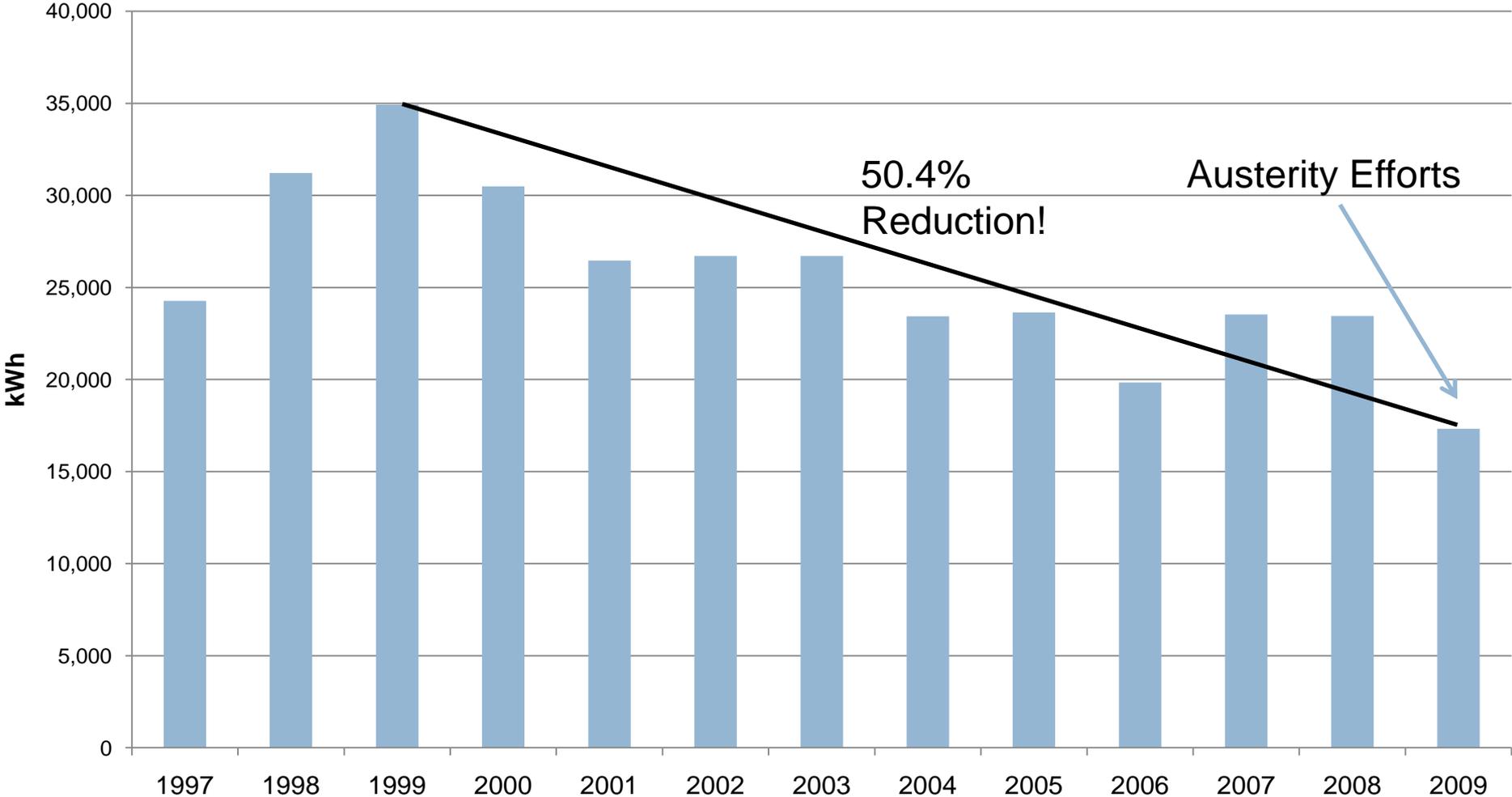


P7 Retrofit Achievements

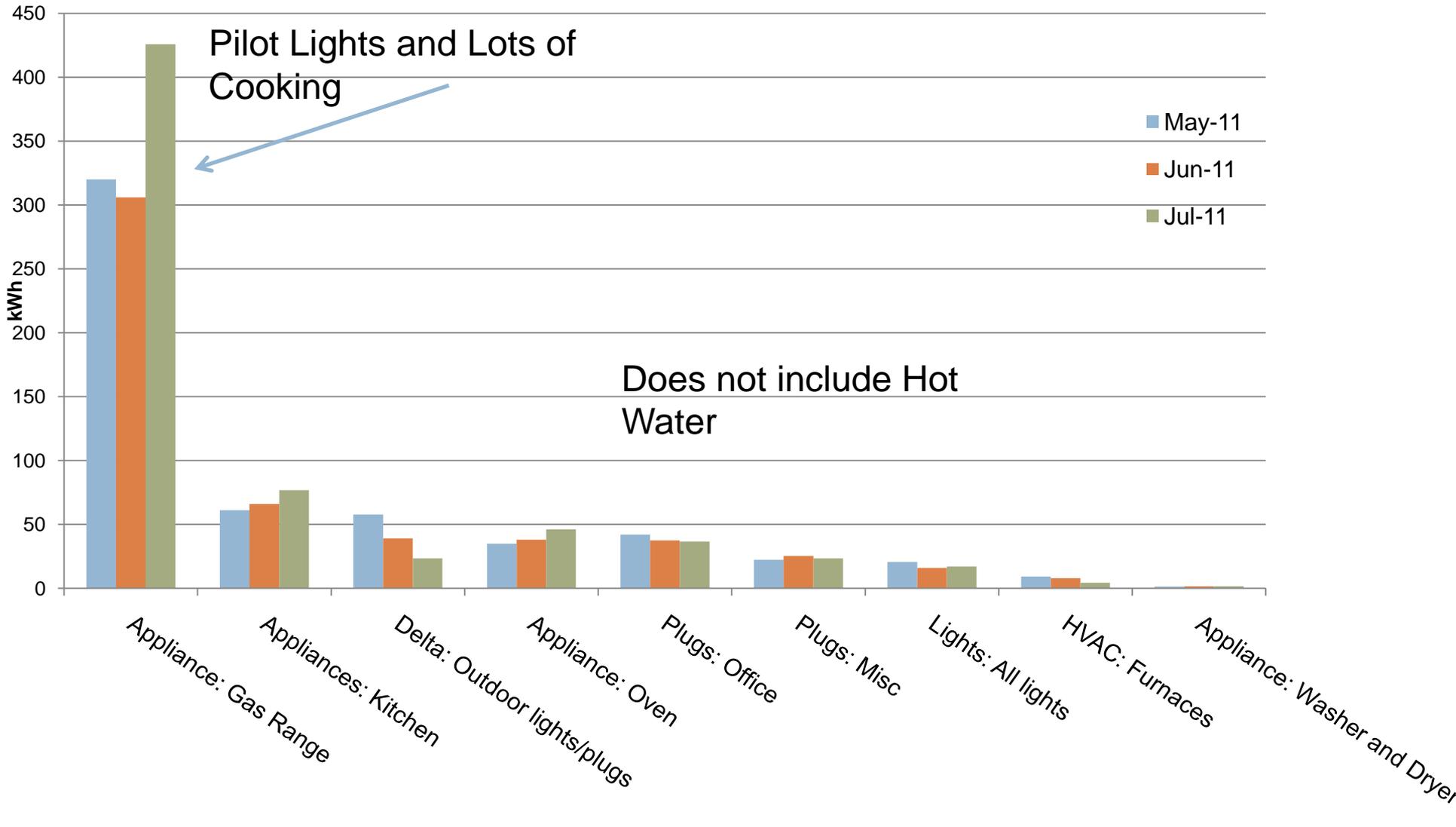
- House within a house concept
- Preserved existing interior
- Low energy user behavior (except for cooking)
- Seismic, foundation and drainage improvements
- High quality construction practices

P7 Historical Utility Bill Data

Total Energy Usage (kWh)



P7 Energy Use Data



P8 Project Description

1915 Craftsman Bungalow Oakland, CA

Pre: 1440ft² → Post: 1440ft²

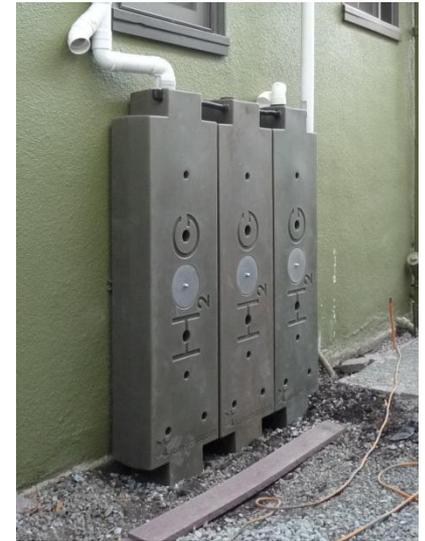
- Super Green Retrofit—
LEED Platinum rated,
greywater, rainwater,
sustainable materials
and landscaping, low
flow fixtures + energy
efficiency
- 3 bedroom, 1.5 bath,
4 Occupants



P8 Retrofit Description



Source: <http://www.elledecor.com/home-remodeling/articles/greenest-little-house-america>



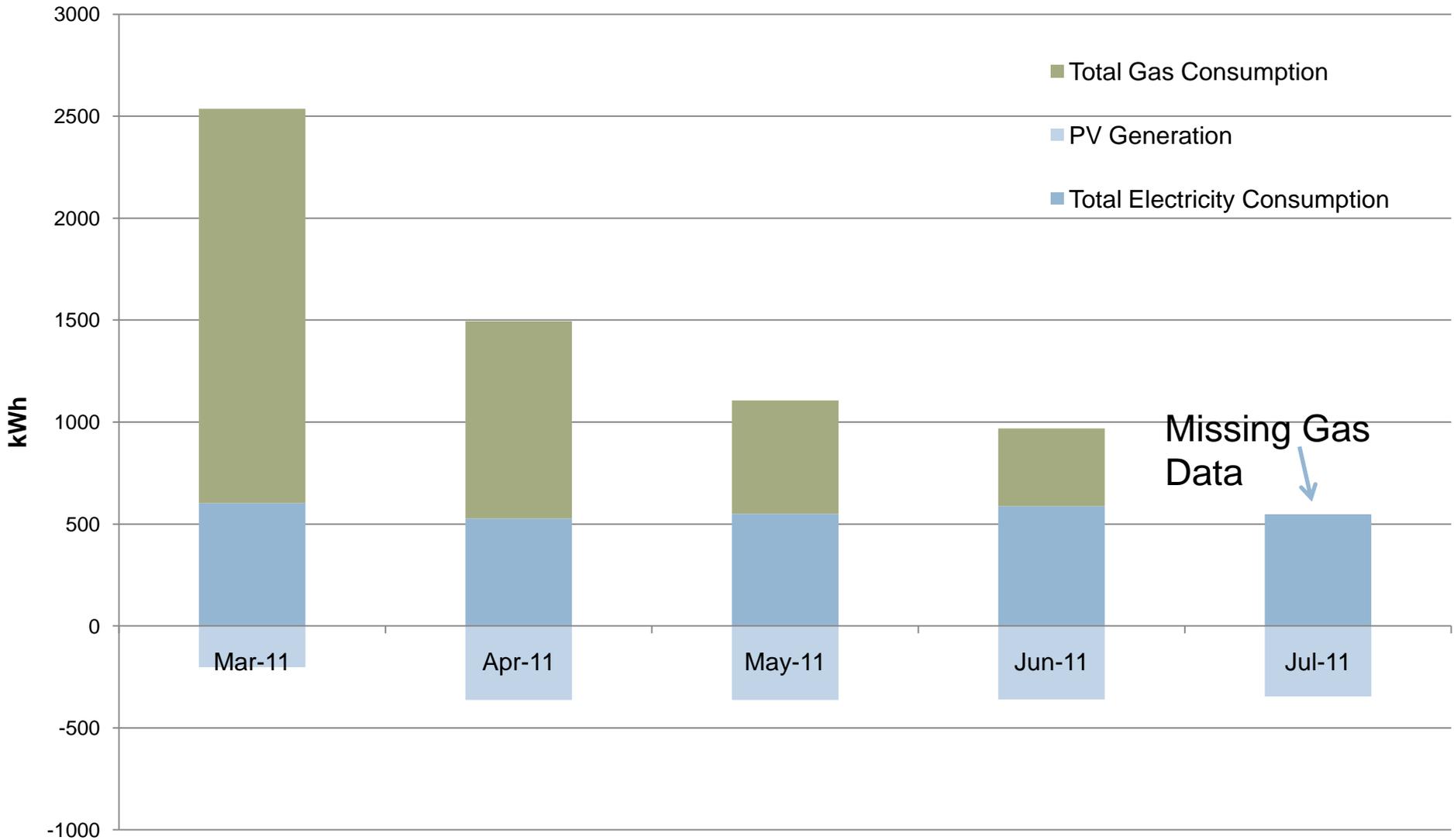
P8 Retrofit Description



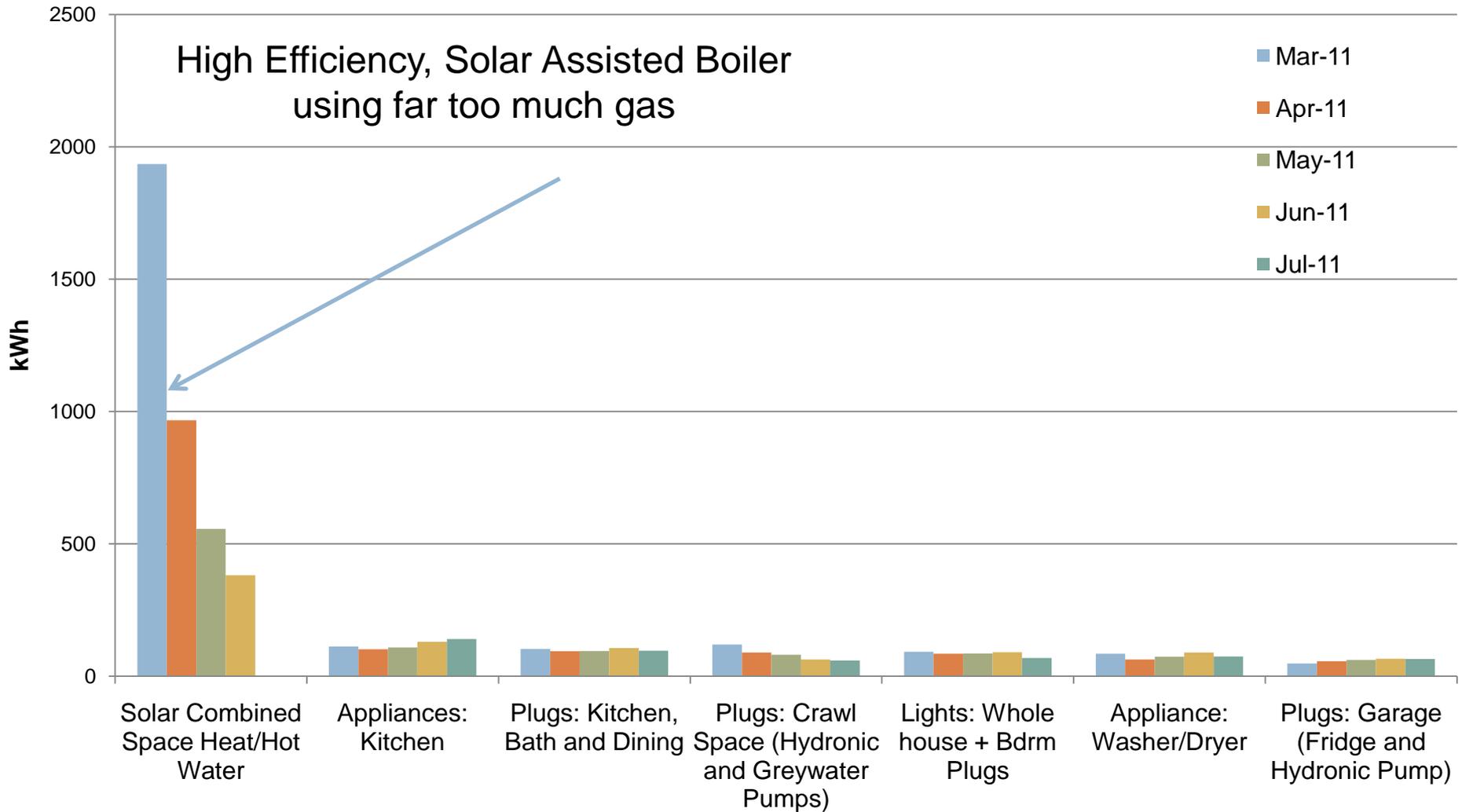
P8 Retrofit Achievements

- Super “Green” Retrofit
- LEED Platinum
- Maintained historical character of interior
- Did not increase building footprint

P8 Energy Use Data



P8 Energy Use Data



P9 Project Description

1998 Tract Home

Folsom, CA

Pre: 2850ft² → Post: 2850ft²

- SMUD Advantage home with a significant energy upgrade and a kitchen remodel.
- Increased insulation, air sealed, lighting retrofit and an extensive HVAC overhaul.
- 3 bedroom, 2.5 bath, 4 Occupants



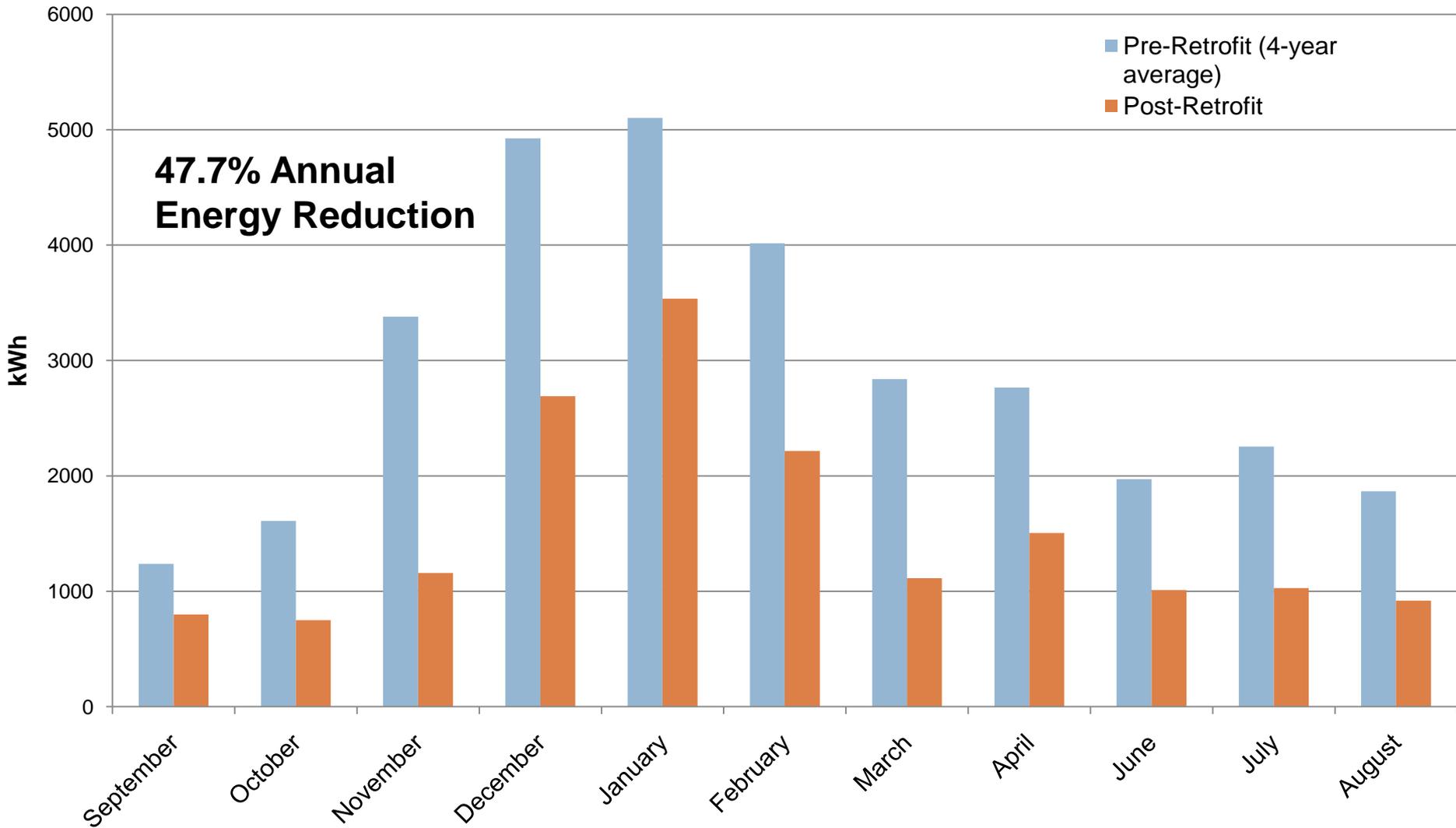
P9 Retrofit Description



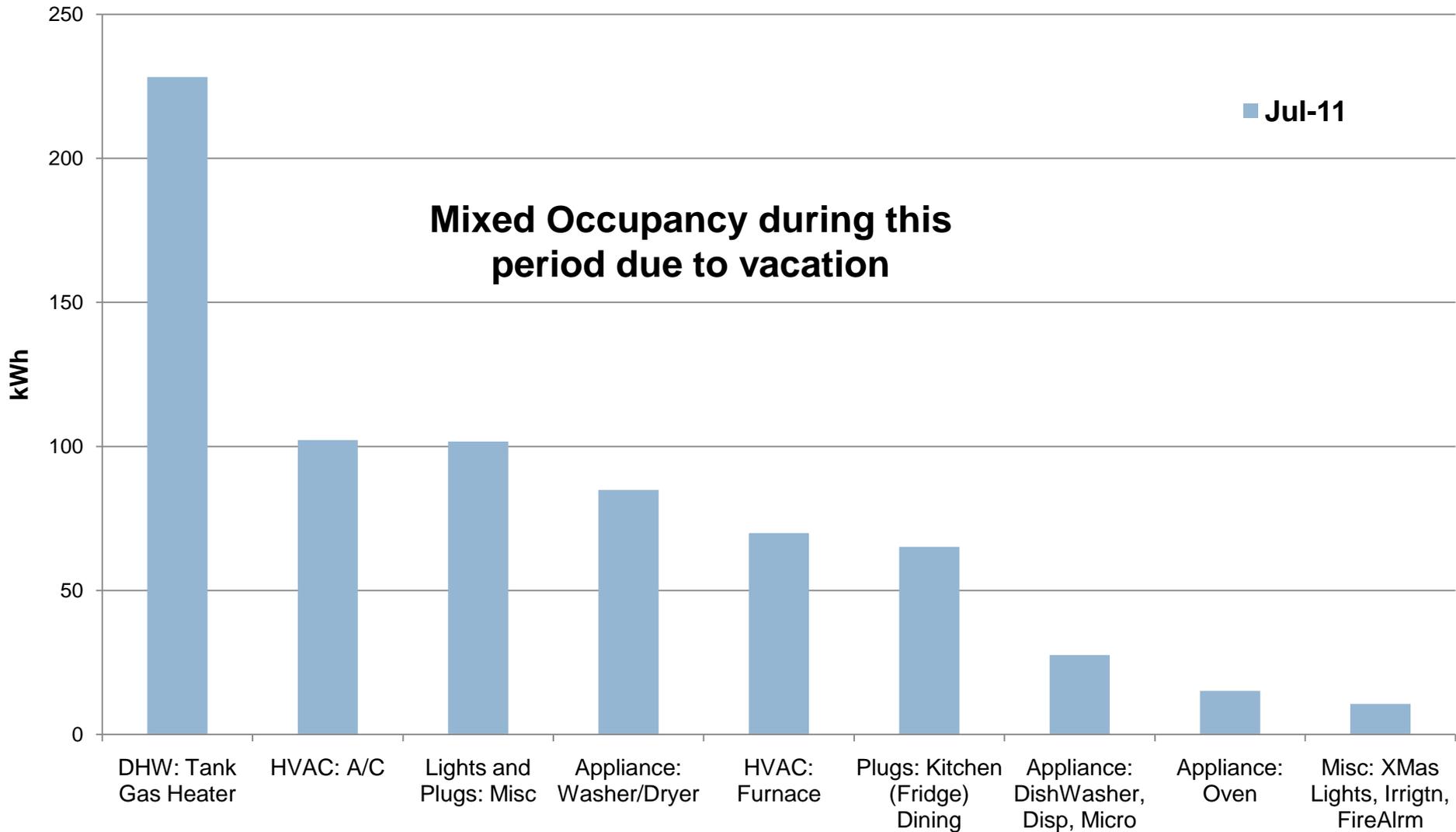
P9 Retrofit Achievements

- Total kWh savings: 59%
- Total therm savings: 41%
- Total electric and gas cost savings at 2008 rates: \$1,260 per year
- Air infiltration reduction by 36% cfm50
- Low cost, minimally intrusive and very successful retrofit

P9 Historical Utility Bill Data



P9 Energy Use Data



P10 Project Description

1938 Cottage

Pacifica, CA

Pre: 1440ft² → Post: 1745ft²

- Family built “Shamrock Shack” remodeled for retirement with goals of resource and energy efficiency, while maintaining original charm with modern comforts.
- 2 bedroom, 1.5 bath, 2 Occupants



Images courtesy of Jim Kremer and regreenprogram.org



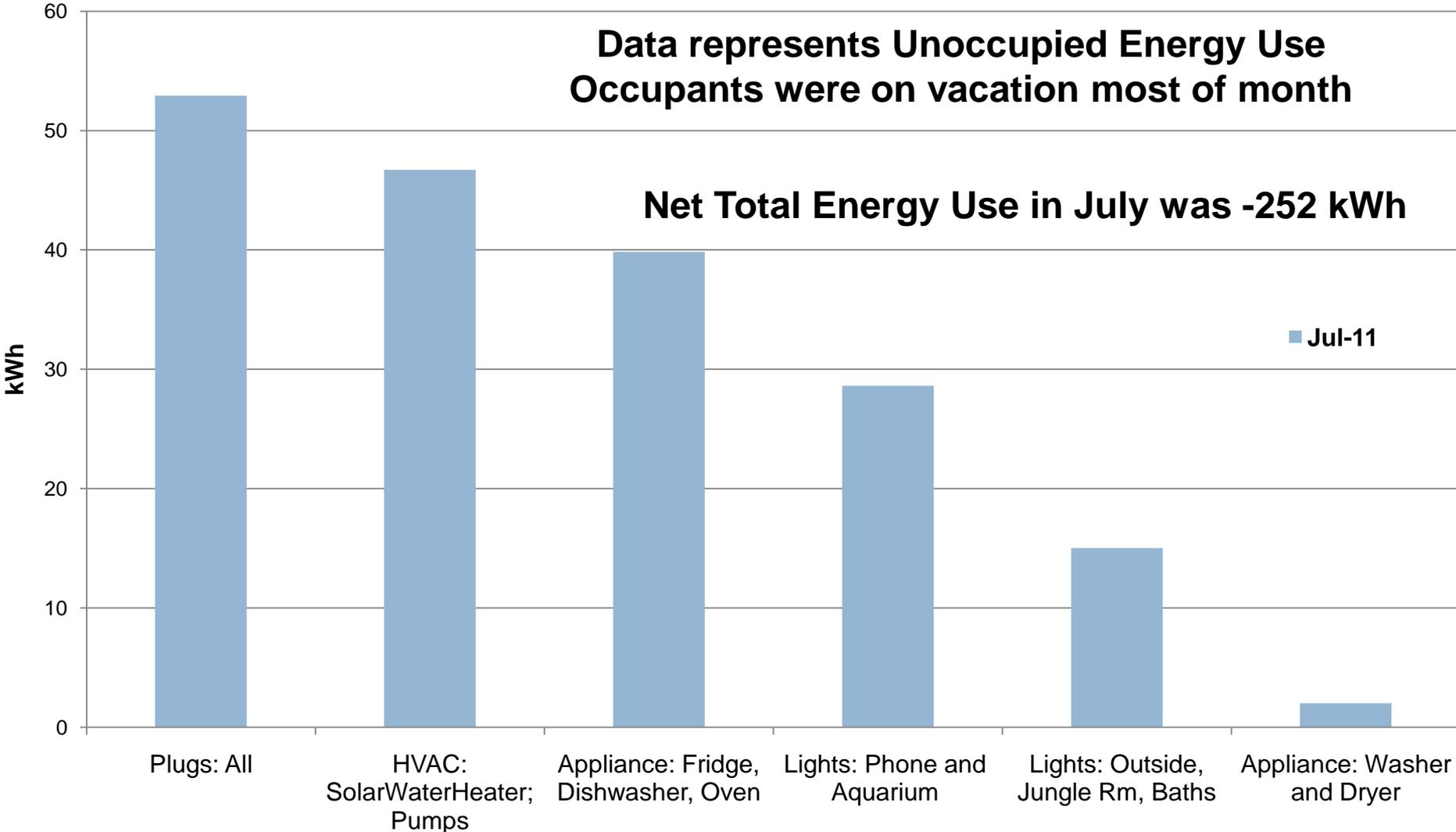
P10 Retrofit Description



P10 Retrofit Achievements

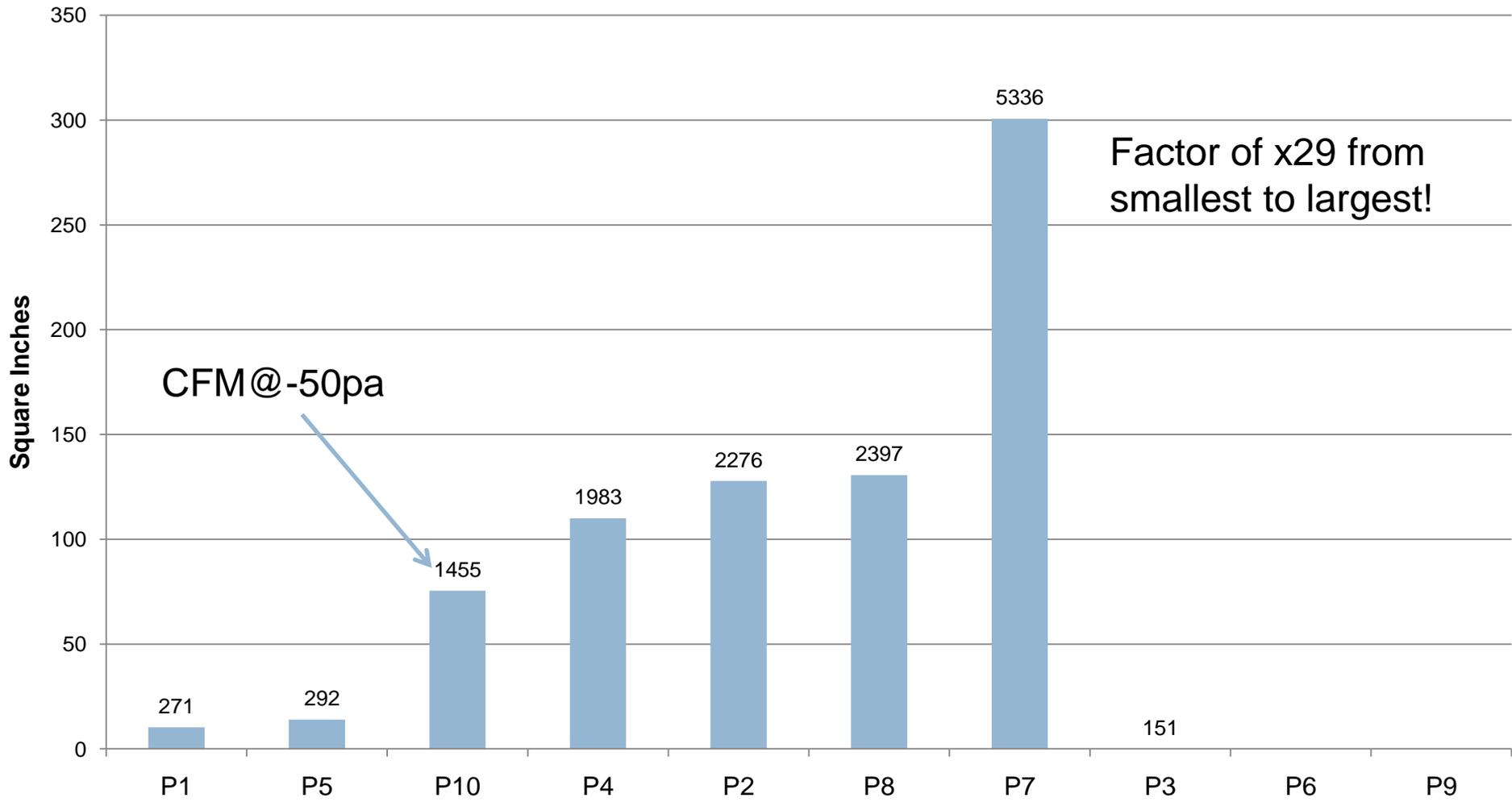
- Greatly increased comfort of home
- Changed interior layout to be far more functional
- Installed skylights to improve natural lighting
- Material re-use
- Water efficient fixtures

P10 Energy Use Data

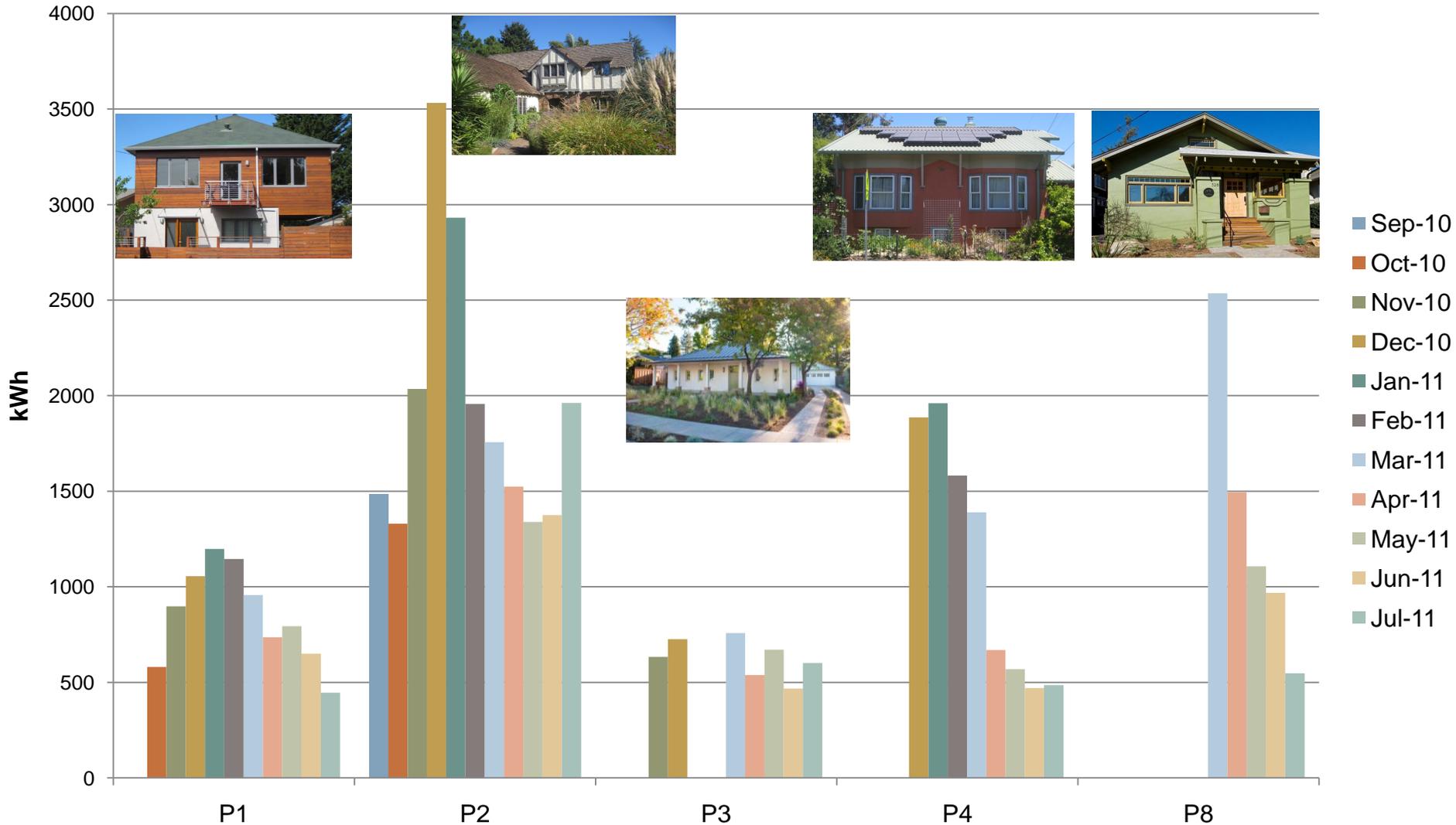


Project Comparison-Air Tightness

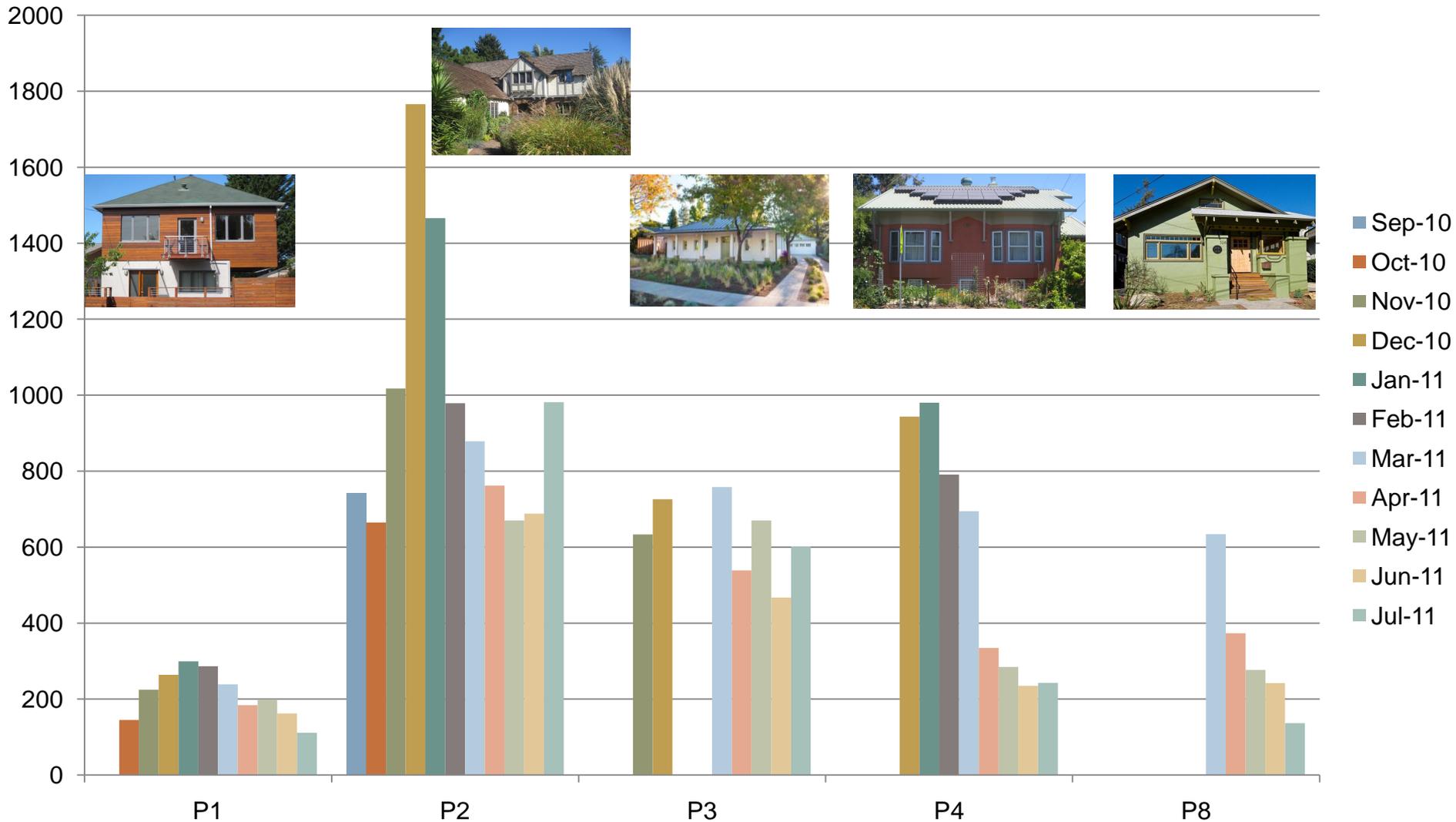
Effective Leakage Area



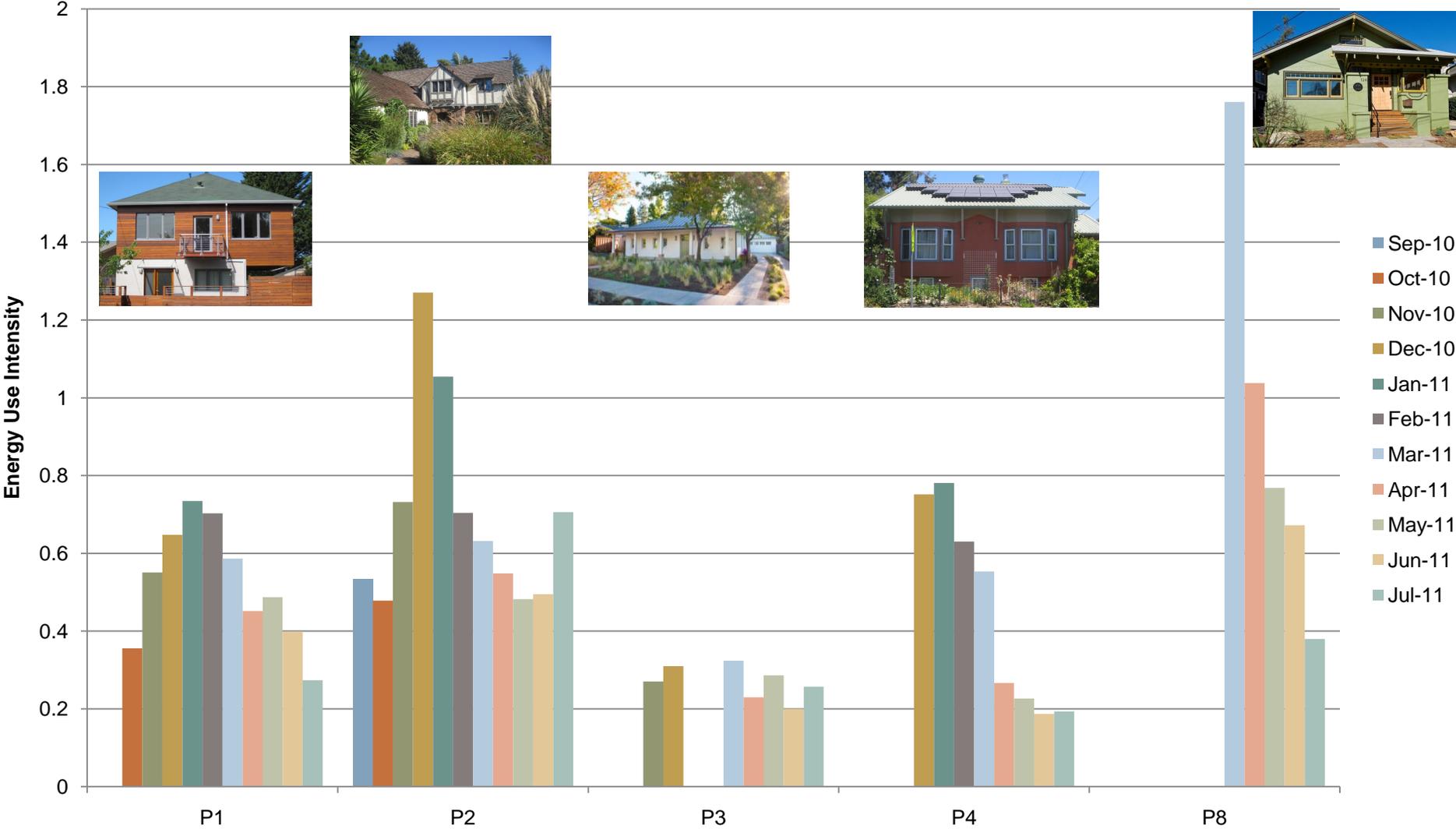
Total Energy Consumption



Energy Per Occupant



Energy Per Square Foot



Final Thoughts

- Deep savings are achievable using a variety of current technologies
- Simple approaches are better than complex ones
- Low energy user behavior is essential to success
- Once you reduce heating and hot water, discretionary energy should be targeted for reduction